

A new fissiparous micro-asteriid from southern Australia (Echinodermata: Asteroidea: Asteriidae)

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Abstract

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The fissiparous micro-asteriid *Allostichaster palmula* Benavides-Serrato and O'Loughlin sp. nov. from south-eastern Australia is described. The diagnostic characters of juveniles of the four other shallow asteriid genera and species from south-eastern Australia are discussed: *Allostichaster polyplax* (Müller and Troschel); *Coscinasterias muricata* Verrill; *Smilasterias multipara* O'Loughlin and O'Hara; *Uniophora granifera* (Lamarck). Diagnostic characters are tabulated. Photos are provided. Fissiparity in these asteriids is noted. The R/r ratio is discussed.

Keywords

Echinodermata, Asteroidea, Asteriidae, *Allostichaster*, new species, fissiparity, taxonomy

Introduction

The rocky littoral and shallow sublittoral coast of south-eastern Australia has been surveyed thoroughly for marine invertebrates. As a result, Museum Victoria houses many small juvenile asteroid specimens. In this study the juveniles of the family Asteriidae were isolated and determined. Four asteriid species occur abundantly on this coast, and are represented in the museum collections by many juveniles: *Allostichaster polyplax* (Müller and Troschel, 1844); *Coscinasterias muricata* Verrill, 1867; *Smilasterias multipara* O'Loughlin and O'Hara, 1990; *Uniophora granifera* (Lamarck, 1816). During this study small specimens of a fifth asteriid fissiparous species were found. This species is new to science, and is represented by seven very small specimens. Recently a live specimen was found in Port Phillip Bay, and photographed.

For comparative diagnoses, small juveniles of all five asteriid species were compared, and photographed by Chris Rowley using a Leica MZ16 stereomicroscope, Leica DC500 digital camera, and “Auto-Montage” software for composition of images. Museum Victoria (NMV) registration number prefix is F.

Forcipulatida Perrier, 1844

Remarks. In diagnosing the Forcipulatae, Perrier (1844) referred to the 2-valved pincer-like pedicellariae, frequent 4 rows of tube feet, normally reticulate skeleton, and at least part cover of spines that are rarely granular. Subsequently Fisher (1928) noted for the order Forcipulata: stellate form with

5 or more arms, frequently long and slender; crossed and/or straight pedicellariae; reticulate skeletal plates in definite longiseries with marginal and carinal series usually regular; ambulacral and adambulacral plates equal in number, short and crowded, compressing the double series of tube-feet into 2 zigzag, 4 or even 6 longiseries; mouth plates frequently inconspicuous, sunken in actinostome. Recently Liao and Clark (1995) followed Blake (1987), and diagnosed the order Forcipulatida as having “disc relatively small, often well-defined, and arms almost cylindrical, marginals not conspicuous, inferomarginals aligned ventrolaterally; abactinal skeleton usually reticulate but sometimes compact, at least a carinal longitudinal series more or less evident; ambulacral plates numerous, very short, often staggered, at least proximally, to bring the suckered tube feet into four longitudinal series; oral plates narrow; papulae also present on lower side; pedicellariae consisting of a basal piece and two valves, either straight or crossed, or both”. Our observations in this study found conspicuous marginal plates on some species, and did not always find papulae on the lower side. We question these recent diagnostic characters of the Forcipulatida.

Asteriidae Gray, 1840

Remarks. Gray (1840) diagnosed his family Asteriidae as “skeleton netted with a single mobile spine at each anastomosis of the ossicula; body covered with more or less prominent elongate mobile spines”. Fisher (1928) considered the Asteriidae to be a “polyphyletic aggregation of genera placed for

Table 1. Diagnostic distinctions between *Allostichaster palmula* Benavides-Serrato and O'Loughlin sp. nov., *Coscinasterias muricata* Verrill, *Smilasterias multipara* O'Loughlin and O'Hara and *Uniophora granifera* (Lamarck) for specimens with R up to 6 mm.

Diagnostic character	<i>Allostichaster palmula</i>	<i>Coscinasterias muricata</i>	<i>Smilasterias multipara</i>	<i>Uniophora granifera</i>
Number of arms	predominantly 6	predominantly 10	5	5
Fissiparity	fissiparous	fissiparous	non-fissiparous	non-fissiparous
Abactinal plates	closely imbricate	openly reticulate	openly reticulate	closely imbricate
Dorsolateral plates	none	link carinal and superomarginal plates	link carinal and superomarginal plates	none
Carinal series	regular	regular	regular	irregular
Carinal plates	quadrilobed form	oblong-elliptical form	quadrilobed form	trilobed form
Abactinal spinelets	distally widened or columnar; coarsely spinous	styliform; acicular spiniform	sub-capitate to slightly tapered deeply serrate	globose and subcolumnar form; finely spinous
Pedicellariae	crossed abactinally, straight in furrow	crossed around spines only	crossed only, not in furrow	crossed only, not in furrow
Superomarginal plates	lobed on proximal edge	cruciform	cruciform	diamond shape
Superomarginal spinelets	up to 3 per plate	one per plate	two per plate	one per plate
Inferomarginal spines	single, broad blade distally	two styliform	one truncate, not flared	two globose
Actinal plates	none	long series	none	proximal to disc only

Table 2. Diagnostic distinctions between *Allostichaster palmula* Benavides-Serrato and O'Loughlin sp. nov. and *Allostichaster polyplax* (Müller and Troschel) for specimens with R up to 6 mm.

Diagnostic character	<i>Allostichaster palmula</i>	<i>Allostichaster polyplax</i>
Form of arms	broad, not tapering, blunt	narrow, tapering, pointed
Abactinal spinelets	distally widened or columnar, coarsely spinous	mostly globose, few columnar, finely spinous distally
Form of carinal plates	quadrilobed	triangular
Superomarginal plates	proximal lobe prominent	lacking prominent proximal lobe
Inferomarginal plates	predominantly monacanthid	predominantly diplacanthid
Inferomarginal spines	narrow basally, short broad blade distally	elongate club-shaped
Adambulacral spines	pairs per plate digitiform, subequal	subambulacral spine broader than furrow spine

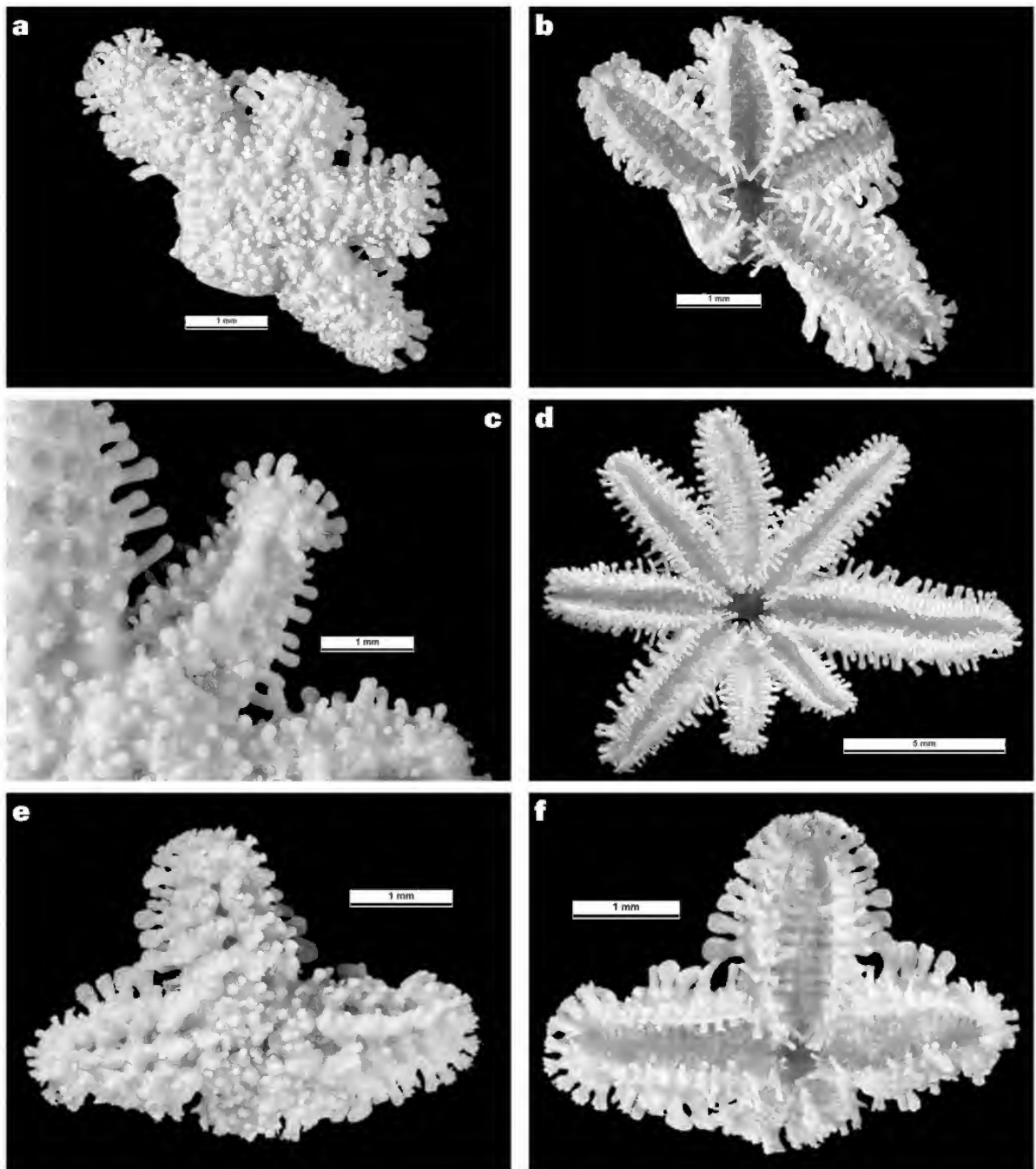


Figure 1. a, b. *Allostichaster palmula* Benavides-Serrato and O'Loughlin sp. nov. (NMV F113585, holotype): a, abactinal view showing blunt arms, post-fissiparous form, paddle-like inferomarginal spines; b, actinal view showing evidence of 6 arms (2 large, 2 small, 2 detached not shown). c, d. *Allostichaster polyplax* (Müller and Troschel) (F73988): c, abactinal view of regenerating arm showing clavate marginal spines; d, actinal view showing post-fissiparity form and typical 8 arms. e, f. *Allostichaster palmula* (NMV F113566, paratype): e abactinal view showing post-fissiparous form, carinal series, papular spaces, and paddle-like inferomarginal spines; f, actinal view showing 3 normal blunt arms and 2 detached not present.

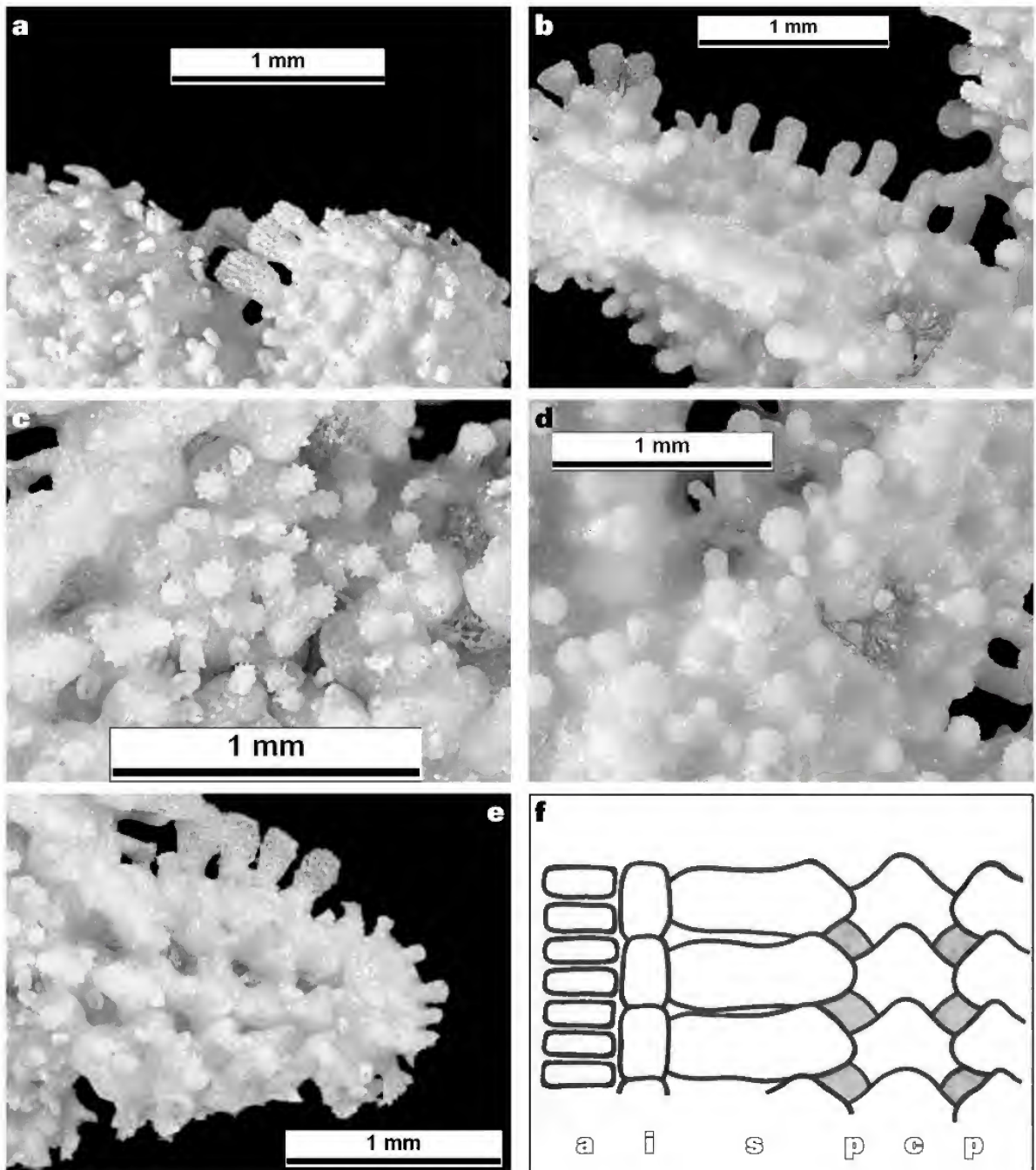


Figure 2. a. *Allostichaster palmula* sp. nov. (NMV F113585): abactinal view showing 2 typical inferomarginal spines (centre) with distinct stem, broad flat blade with vertical and radiating ribs, and coarsely serrate distal edge. b. *Allostichaster polyplax* (F73988): abactinal view showing clavate inferomarginal spines. c. *Allostichaster palmula* (NMV F113566): abactinal view of disc showing distally widened, coarsely spinous, spinelets, and small crossed pedicellaria (top). d. *Allostichaster polyplax* (F73988): abactinal view of proximal arm showing finely spinous globose and subcolumnar spinelets, and small crossed pedicellaria (top). e. *Allostichaster palmula* (NMV F113566): abactinal view of arm showing carinal series, papular spaces, and typical paddle-shaped inferomarginal spines (top). f. diagram showing typical skeletal plates of an arm of *Allostichaster palmula*: a, adambulacral; i, inferomarginal; s, superomarginal; p, papular space (shaded); c, carinal (proximal ray at top).

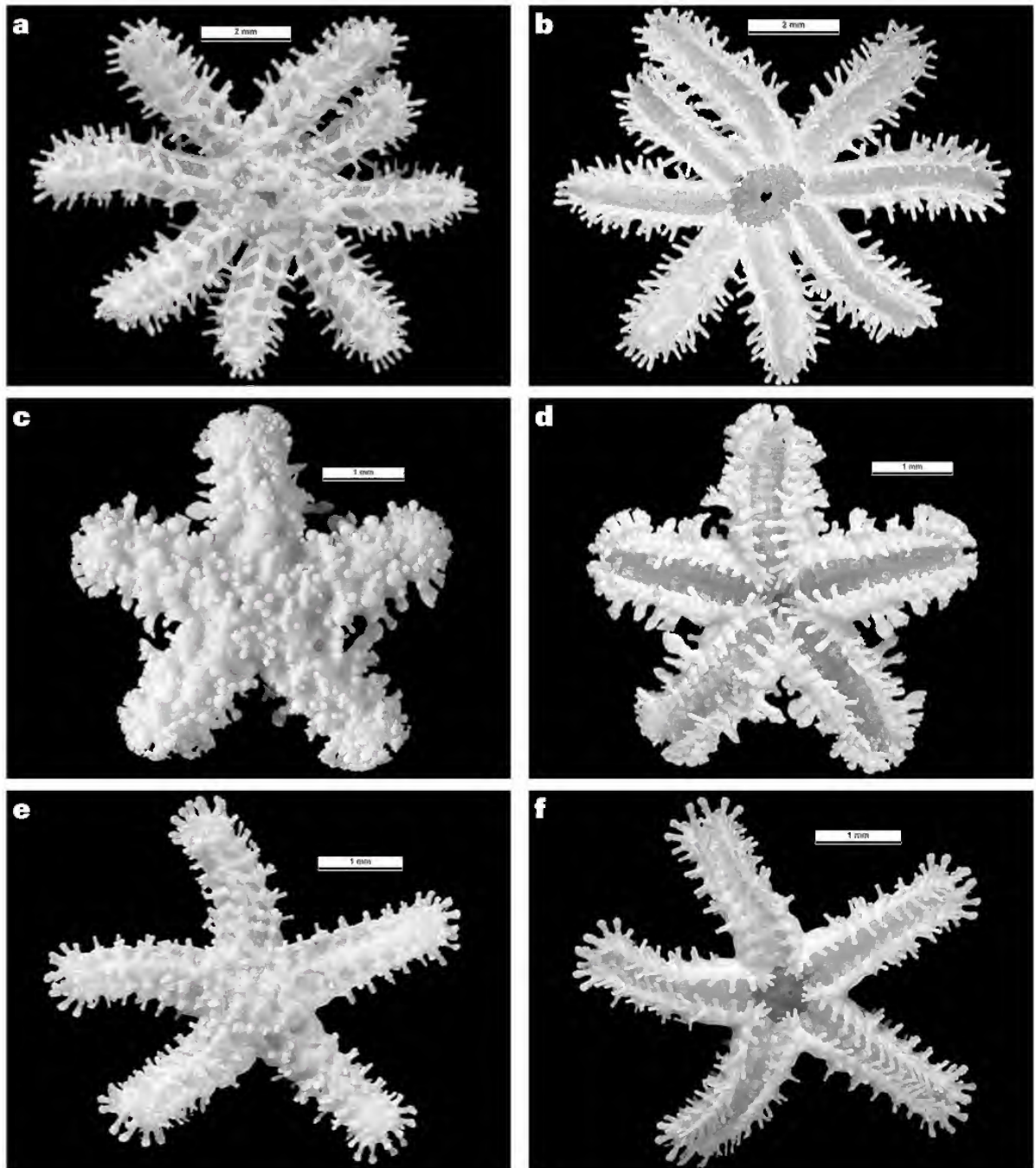


Figure 3. Asteriid species of the rocky shallows of the coast of Victoria. a, b. *Coscinasterias muricata* Verrill (NMV F73314): a, abactinal view showing unequal arm lengths (fissiparous when juvenile), alternating spiniferous and non-spiniferous small carinal plates, and digitiform thin marginal spines; b, actinal view showing 10 arms (2 very small regenerating) of a typically 11 arm species. c, d. *Uniophora granifera* (Lamarck) (NMV F113567): c, abactinal view showing typical 5 equal rays, globose abactinal spinelets, and globose marginal spines; d, actinal view showing globose spines with distinct stem. e, f. *Smilasterias multipara* O'Loughlin and O'Hara (NMV F121895): e, abactinal view showing typical 5 equal rays, digitiform thin marginal spines; f, actinal view.



Figure 4. Live specimen of *Allostichaster palmula* sp. nov. from 10–12 m at Popes Eye in Port Phillip Bay (NMV F132700; R = 1.2 mm; 5 equal rays at this smallest size; photo by Trevor McMurrich).

convenience under the aegis of *Asterias*". He characterized the family as having usually 5 or 6 rays, 5 primary longitudinal series of plates (carinal, 2 superomarginal, 2 inferomarginal), generally reticulate dorsal skeleton, crowded ambulacral plates, and mostly 2 or 4 longiseries of tube feet. A.M. Clark (1962) characterized the Asteroiidae as having: usually 4 series of tube feet, short adambulacral plates, usually straight pedicellariae at least in the furrow, marginal spines not needle-like. Most recently McKnight (2006) diagnosed the family as "Forcipulatida with five or more arms, usually merging into the disc, sometimes more sharply set off from it. Abactinal skeleton reticulate, with longitudinal and transverse series of plates, or reduced to isolated plates, in no apparent order. Skeleton extending to tip of rays, the plates armed with one or more spines or spinelets. Adambulacral plates short, with the spines in a single transverse series, usually one or two, but up to seven may be present. Tube feet in two or four rows". The morphological characters of the asteriid species in this study are in accord with these diagnoses.

Allostichaster Verrill, 1914

Remarks. Verrill (1914) erected his genus for *A. polyplax*, and diagnosed the genus as "diplacanthid and multiple rayed, with one to five madreporic plates, and is probably autotomous. The two rows of marginal plates are stout and imbricated; dorsal plates and spines form five somewhat irregular longitudinal rows, several short, obtuse spines on each plate. Minor pedicellariae are dermal, usually not circumspinal". Fisher (1923) characterized *Allostichaster* as having: carinals and superomarginals broader than other plates; narrow dorsolateral area; fissiparous habit; superomarginal plates with beaded surface. A.M. Clark (1962) noted for *Allostichaster*: rarely as few as 5 arms; fissiparous habit; narrow dorso-lateral area. Most recently McKnight (2006) diagnosed the genus as "Asteroiidae with the abactinal crossed pedicellariae scattered, not in circumspinal wreaths; skeleton closeknit, plates in definite longiseries; carinals and superomarginals broader than other plates; adradial plates narrow, in a single straight or zigzag series; inferomarginals form edge to arm; one series of

actinal plates. Adambulacral plates usually diplacanthid; cleaned superomarginal plates with beaded area; multiple madreporites, fissiparous, rays 5–8, often in 2 sizes". We found the morphological characters of *Allostichaster polyplax* to be in accord with these diagnoses.

Allostichaster palmula Benavides-Serrato and O'Loughlin sp. nov.

Figures 1–4, Tables 1, 2.

Material examined. *Allostichaster palmula* Benavides-Serrato and O'Loughlin sp. nov. Holotype: SE Australia, Victoria, E Western Port, San Remo, N of bridge, bank of main channel, shallows, soft sediment or rocky substrate, Marine Research Group of Victoria, 13 Jan 1990, NMV F113585 (dry, 6 arms; disc and 4 arms intact, 1 arm detached and cleared of integument, 1 arm detached uncleared; max R = 2.5 mm, r = 1 mm, R/r = 2.5).

Paratypes: E Victoria, Mallacoota, MSL Abalone Survey, VAC SIQ2, 24 May 1987, F120432 (1, dry, 6 arms, 3 long, 3 very short, whole specimen cleared of integument; max R = 5 mm, r = 1 mm, R/r = 5); N Western Port, WBES Stn 1704, Bouchier Channel, S-M Grab, 12 m, sand, 9 Jan 1974, F87056 (1, dry, 3 arms; disc and 1 arm complete, 2 arms detached; max R = 2.5 mm, r = 0.5 mm, R/r = 5); NW Western Port, between Stony Point and Tankerton, dredge, 12 Nov 1974, F86026 (1, dry, 6 arms; disc with 2 arms complete; 4 detached arms; max R = 3 mm, r = 0.5 mm, R/r = 6); W Western Port, dredged off Cowes, 2–5 m, 1977, F86023 (1, dry, 6 arms; disc and 5 arms complete, 1 arm detached; max R = 4 mm, r = 1 mm, R/r = 4); Port Phillip Bay, Popes Eye, 10–12 m, found eating encrusting bryozoan *Membranipora* on brown alga frond, J. Watson, R. Burn, T. McMurrich, 29 Apr 2007, F132700 (1, alc, 5 arms, max R = 1.2 mm, r = 0.7 mm, R/r = 1.7); 6–10 m, J. Watson, R. Burn, from alga, sponge, hydroid, bryozoa sample, 6 Aug 2006, F113566 (1, dry, 5 arms; disc and 3 arms complete; max R = 2 mm, r = 1 mm, R/r = 2).

Allostichaster polyplax (Müller and Troschel, 1844). Victoria, 1 km E of Harmers Haven, CPA Stn 15, 300 m offshore, off algae, 6 Mar 1982, NMV F120422 (2, alc; 1 with 6 arms, max R = 6 mm, r = 1.5 mm, R/r = 4; 1 with 6 arms, max R = 5.5 mm, r = 2 mm, R/r = 2.75); Western Port, Crib Point Benthic Survey, CPBS Stn 03 S, 2 m, sandy-mud, 13 Apr 1965, F71968 (2, dry; 1 with disc and 3 arms complete, 1 detached, max R = 3 mm, r = 1 mm, R/r = 3; 1 with 6 arms, 3 long, 3 very short, max R = 3 mm, r = 1 mm, R/r = 3); CPBS Stn 12 N, mud and *Zostera*, 16 Apr 1965, F71967 (1, alc, 3 arms, 2 long, 1 very short, max R = 8 mm, r = 1 mm, R/r = 8); CPBS, Stn 10 O, 4 m, mud and *Zostera*, 24 Apr 1965, F71969 (1, dry, 7 arms; max R = 6 mm, r = 1 mm, R/r = 6); Flinders, rocky shallows, 13 Apr 1985, F120423 (1, alc, 5 arms, 3 long, 2 very short, max R = 6 mm, r = 1 mm, R/r = 6); Port Phillip Bay, Environmental Study Benthic Survey, PPBS Stn 953, 3 m, sand, 11 Jun 1971, F71975 (1 dry, 4 arms, 2 detached, max R = 7 mm, r = 1 mm, R/r = 7); Popes Eye, rocky shallows, 30 Nov 1980, F73409 (1, dry, 5 arms, disc and 4 arms complete, max R = 9 mm, r = 3 mm, R/r = 3); Point Cook, shallows, F73405 (2, dry; 1 with 7 arms, 5 long, 2 very short, max R = 9 mm, r = 1 mm, R/r = 9; 1 with 8 arms, max R = 8 mm, r = 2.5 mm, R/r = 3.2); Tasmania, Derwent R. estuary, Opposum Bay, rocky shallows, 15 Nov 1982, F73988 (1, dry, 8 arms, max R = 8 mm, r = 2 mm, R/r = 4).

Coscinasterias muricata Verrill, 1867. Victoria, Point Hicks, subtidal rocky reefs, 10 m, 26 Mar 1996, F113590 (1, dry, 5 arms; max R = 4 mm, r = 1 mm, R/r = 4); Flinders ocean platforms, algal epifauna, 0–2 m, 11 Aug 1990, F72193 (1, dry, integument cleared, 7 arms, 6 long, 1 very short, max R = 7 mm, r = 1 mm, R/r = 7); Port Phillip Bay, Popes Eye, off algae, 30 Nov 1980, F73314 (1, dry, 10 arms, 8 long, 2

very short, max $R = 6$ mm, $r = 1$ mm, $R/r = 6$); Western Australia, Albany, Princess Royal Harbor, 1.6 m, 21 Jan 1988, F121890 (1, alc, 8 arms, max $R = 5$ mm, $r = 1.5$ mm, $R/r = 3.33$).

Smilasterias multipara O'Loughlin and O'Hara, 1990. Victoria, Flinders ocean platforms, rocky shallows, 26 Feb 2000, F121895 (7, alc; 1 dry, 5 arms, max $R = 2.5$ mm, $r = 0.8$ mm, $R/r = 3.13$).

Uniophora granifera (Lamarck, 1816). Victoria, Bunurong, off Cape Paterson, subtidal rocky reefs, 10–11 m, 1 Apr 1997, F113567 (1, dry, 5 arms, max $R = 2$ mm, $r = 1$ mm, $R/r = 2$); South Australia, Rapid Bay jetty, sand, rubble, 12 m, 7 Apr 1980, F126862 (1, dry, 5 arms, max $R = 9$ mm, $r = 2$ mm, $R/r = 4.5$); Smoky Bay, 12 m, sand and weed, 25 Apr 1973, F120434 (1, dry, cleared of integument, max $R = 8$ mm, $r = 2$ mm, $R/r = 4$).

Description. 6 discrete arms, or 5 (2 smallest); arms wide, not tapering, rounded distally, max $R = 5$ mm, $r = 1$ mm, $R/r = 5$ (F120432); 6 specimens show post-fissiparous form, smallest non-fissiparous; madreporites inconspicuous; arms flat actinally, domed abactinally; margin acute, defined by inferomarginal plates; oral plates inconspicuous; abactinal plates thick, imbricate; disc plates irregular in form, imbricate, larger than carinal plates, irregularly arranged; longitudinal regular series of quadrilobed carinal plates, narrowly imbricating longitudinally, imbricating with superomarginal plates laterally; rare small dorso-lateral plates; superomarginal plates largest, regular longitudinal series, plates transversely elongate, proximal lobes narrowly imbricating longitudinally, narrowly imbricating laterally with carinal and inferomarginal plates; papular areas distinct, smaller than plates, 2 longitudinal series between carinal and superomarginal plates; inferomarginal plates longitudinally elongate; lacking actinal plates; adambulacral plates transversely narrow, about 2–3 contiguous with each inferomarginal plate; 2 contiguous proximal adambulacral plates forming adoral corona; tube feet quadriseriate.

About 2–3 spinelets per disc, carinal or superomarginal plate; spinelets widened distally or columnar, coarsely spinous distally; spinelets distributed irregularly over abactinal surface of arms and disc; crossed pedicellariae present abactinally and marginally, smaller than spinelets, not associated with individual spinelets, scattered amongst spinelets; inferomarginal plates predominantly monacanthid, rarely diplacanthid; inferomarginal spines project widely from the margin, each with proximal stem and distal broad flat blade with vertical and radiating ribs, blade distally slightly rounded and strongly serrate; adambulacral plates diplacanthid, single series of subambulacral spines, single series of furrow spines, pairs typically forming a “V”; adambulacral spines subequal, shorter than inferomarginal spines, subclavate, subspatulate, distinctly spinous distally; some straight pedicellariae scattered in furrow, larger than crossed pedicellariae.

Colour (live). Upper proximal rays and disc brown, lower and distal rays white, inferomarginal spines brown.

Distribution. SE Australia, Mallacoota to Port Phillip Bay, sediment, 0–12 m.

Etymology. From the Latin *palmula* (blade of an oar), referring to the distinctive form of the inferomarginal spines.

Remarks. *Allostichaster palmula* shares many diagnostic characters with the other local shallow asteriid species *Allostichaster polyplax*, *Coscinasterias muricata*, *Smilasterias multipara* and *Uniophora granifera*: stellate form with discrete rays; 5 primary longiseries of plates (1 carinal, 2 superomarginal, 2 inferomarginal); abactinal skeleton of transverse arches on arms, forming a network of rectangular or irregular mesh; both series of marginal plates well developed; crossed and straight pedicellariae; tube-feet in 4 longiseries. The diagnostic distinctions between these species are listed in Tables 1 and 2.

Allostichaster palmula and *A. polyplax* share many characters at R up to 6 mm: fissiparity; predominantly 6 rays; large, thick, imbricate abactinal plates; prominent abactinal series of carinal and superomarginal plates; lack dorsolateral and actinal plate series; superomarginals are largest plates; paired longitudinal series of prominent papular spaces abactinally; scattered, distally-widened abactinal spinelets; crossed pedicellariae abactinally; straight pedicellariae in furrow, orally; 2 pairs of post-oral adambulacral plates form adoral corona, with post-oral plates joined along interradiar margins; adambulacral plates diplacanthid, pairs typically forming a “V”, with 2 single series of furrow and subambulacral spines. The diagnostic distinctions between the 2 species are listed in Table 2.

The pedomorphic new species *Allostichaster palmula* exhibits the diagnostic characters of the order Forcipulatida, family Asteriidae, and genus *Allostichaster* referred to above. However, the small specimens do not have actinal plates and madreporite plates were not recognized. As noted above, the marginal plates are conspicuous, and there are no ventrolateral papulae.

For the 3 fissiparous species, R/r ratios vary greatly and reflect the variable regenerating arm lengths following fissiparity: *A. palmula* from 1.7 to 6; *A. polyplax* from 2.8 to 9; *C. muricata* from 3.3 to 7. But with each of these fissiparous species the largest ratio was measured on the largest specimen, suggesting from this limited sample that R/r increases with maximum R . This is true for the 3 specimens of the non-fissiparous *U. granifera*, with R/r increasing from 2 ($R = 2$ mm) to 4.5 ($R = 9$ mm). *A. polyplax* adults have predominantly 8 arms. *C. muricata* adults have predominantly 11 arms. Neither of these maxima was evidenced in specimens below $R = 8$ mm, suggesting that arm number increases with size in these fissiparous species. In the new species *A. palmula* the 2 smallest specimens have only 5 arms, the rest 6 arms. We note that the smallest specimen of *C. muricata* ($R = 4$ mm) has 5 equal arms and does not show evidence of fissiparity, suggesting that fissiparity does not occur until $R > 4$ mm. Likewise the smallest specimen of *A. palmula* ($R = 1.2$ mm) has 5 equal arms and does not show evidence of fissiparity, suggesting that fissiparity does not occur until $R > 1.2$ mm. Other characters are also size-dependent, such as the presence of actinal plates in larger specimens of *A. polyplax*.

O'Loughlin and Rowe (2006) described 2 micro-species of fissiparous Asteriidae, with maximum $R = 5$ mm: *Aquilonastra colemani* from Papua New Guinea and Indonesia, and *Aquilonastra doranae* from Okinawa. *Allostichaster palmula*

is a comparably small-sized micro-asteriid, with maximum $R = 5$ mm. These are the smallest known asteroid species.

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